I. C. 6761

JANUARY, 1934

UNITED STATES BUREAU OF MINES
SCOTT TURNER, DIRECTOR

## INFORMATION CIRCULAR

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BY

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# MINE EXPLOSIONS AND FIRES IN THE UNITED STATES DURING THE FISCAL YEAR ENDED JUNE 30, 1933[1]

By D. Harrington[2] and W. J. Fene[3]

Explosions are a type of mine accident that can be prevented by known methods; however, they continue to occur because some mining people are still negligent in adopting and using the known and, in general, readily available measures for avoiding these disasters. Although the frequency and severity of explosions have decreased during the past 5 years there is still much room for improvement. Pennsylvania is an excellent example of what may be done to prevent explosions; this State had an explosion record by no means good during the decade before 1930, but by the adoption of readily available and not very expensive safety measures it now has almost entirely eliminated explosions. Pennsylvania bituminous mines now have the enviable record of not having had a major explosion disaster in considerably over 4 years. In fact, many of our mining States are showing definite progress in working mines without explosions; and some of these, like Alabama, West Virginia, Wyoming, and others now operating with few if any explosions, have had anything but a favorable record in the past.

## SUMMARY OF MINE EXPLOSIONS BY STATES

Table 1 shows the results of studies of 22 explosions in 10 States, with a total of 122 deaths, during the fiscal year ended June 30, 1933. The number of ignitions (22) is fewer than that (33) for the previous fiscal year; however, the number of deaths (122) is considerably larger than that (87) for the previous year, the increase being due chiefly to one explosion in Illinois which cost 54 lives.

The States with the greatest number of deaths from explosions during the year were Illinois, 54; Kentucky, 26; Pennsylvania, 9 (6 in anthracite mines); West Virginia, 9; Indiana, 4; Oklahoma, 3; Washington, 2; and Colorado, 1. The greatest number of ignitions listed, 6 (5 in anthracite

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6761."

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Table 1. - Summary of mine explosions by States, July 1, 1932 to June 30, 1933

| | Lighting used | | | | Fatalities by ignition causes | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Electricity | | Open lights or smoking | | Explosives | | Unknown | | Total | |
| | Open | Closed | Unknown or no lights | Total mine explo-sions | Deaths | Igni-tions | Deaths | Igni-tions | Deaths | Igni-tions | Deaths | Igni-tions | Deaths | Igni-tions |
| California | 1/ 1 | - | - | 1/ 1 | - | - | - | 1 | - | - | - | - | - | 1 |
| Colorado | - | 1 | - | 1 | 1 | 1 | - | - | - | - | - | - | 1 | 1 |
| Illinois | 1 | - | - | 1 | - | - | 54 | 1 | - | - | - | - | 54 | 1 |
| Indiana | 2 | - | - | 2 | - | - | - | - | 4 | 2 | - | - | 4 | 2 |
| Kentucky | 2 | - | - | 2 | - | - | 3 | 1 | 23 | 1 | - | - | 26 | 2 |
| New Mexico | - | 1 | - | 1 | 14 | 1 | - | - | - | - | - | - | 14 | 1 |
| Oklahoma | 1 | 1 | - | 2 | - | - | 3 | 2 | - | - | - | - | 3 | 2 |
| Pennsylvania | - | 2/ 6 | - | 6 | 1 | 1 | 3 | 3 | - | - | 5 | 2 | 9 | 6 |
| Washington | - | 1 | - | 1 | 2 | 1 | - | - | - | - | - | - | 2 | 1 |
| West Virginia | - | 4 | 1 | 5 | 7 | 4 | - | - | 2 | 1 | - | - | 9 | 5 |
| Total United States, fiscal year ended June 30, 1933 | 7 | 14 | 1 | 22 | 25 | 8 | 63 | 8 | 29 | 4 | 5 | 2 | 122 | 22 |
| Total United States, fiscal year ended June 30, 1932 | 1/15 | 1/15 | 1/4 | 1/34 | 11 | 10 | 33 | 15 | 42 | 5 | 1 | 3 | 87 | 33 |
| Total United States, fiscal year ended June 30, 1931 | 12 | 15 | 0 | 1/26 | 143 | 9 | 56 | 11 | 18 | 6 | 0 | 0 | 217 | 26 |
| Total United States, fiscal year ended June 30, 1930 | 8 | 25 | 1 | 34 | 154 | 18 | 21 | 8 | 24 | 6 | 0 | 2 | 199 | 34 |
| Total United States, fiscal year ended June 30, 1929 | 18 | 19 | 1 | 38 | 93 | 18 | 14 | 11 | 26 | 8 | 6 | 1 | 139 | 38 |

1/ Ignition of methane in a metal mine.

2/ Mixed lights used in one mine.

mines), was for Pennsylvania; West Virginia was next with 5 ignitions; Indiana, Kentucky, and Oklahoma had 2 each; and California, Colorado, Illinois, New Mexico, and Washington had 1 each.

Three major explosions (in which 5 or more men were killed) occurred during the fiscal year, all of them in December 1932; 91 persons were killed. The fact that there were only 8 gas or dust ignitions of electrical origin in the mines of the United States during the past fiscal year compared with an average of 14 for the previous 4 years indicates that greater precautionary measures than in the past have been taken with ventilation and in the installation and use of electrical equipment in mines.

Twenty-five persons were killed during the past fiscal year in mine explosions caused by electricity; this is a much poorer showing than that of the preceding year, when only 11 were killed from this cause; however, each of the last 2 fiscal years shows decided improvement in deaths from explosions of electrical origin compared with the 3 previous fiscal years, in which 143, 154, and 93 persons were killed from mine explosions started by electricity. This indicates a 75 percent reduction in deaths from explosions of electrical origin over the average for the 4 fiscal years 1929 to 1932, inclusive, which denotes not only increased precautions in the use of electricity underground but also that rock-dusting is now performing a very useful function in our coal mines in helping to prevent dust ignitions and in stopping gas explosions from picking up inflammable dust to extend or propagate explosions.

West Virginia had the greatest number of electrical ignitions (4), with 7 fatalities; New Mexico had 1 electrical ignition, with 14 fatalities; Washington had 1 electrical ignition, with 2 fatalities; and Colorado and Pennsylvania each had 1 electrical ignition, with 1 fatality.

Eight ignitions were caused by open lights (1 in a metal mine, burning 2 men) compared with 15 in the previous fiscal year and an average of 14 during the previous 4 fiscal years. The deaths last year numbered 64 (54 in one explosion) compared with 33 the previous year and an average of 31 during the previous 4 years. Ignitions from open lights were distributed by States as follows: Illinois, 1, with 54 deaths; Pennsylvania, 3, with 3 deaths; Oklahoma, 2, with 3 deaths; Kentucky, 1, with 3 deaths; and California, 1, with no fatalities. Explosions originated by blasting with explosives numbered 4, with 29 fatalities, compared with 5 ignitions from explosives, with 42 fatalities, for the previous year and an average of 6 ignitions and 30 fatalities for the previous 4 years. One ignition from explosives in Kentucky resulted in the death of 23 persons, while 2 ignitions in Indiana killed 4 and 1 ignition in West Virginia killed 2.

Two explosions in which the cause of ignition could not be determined occurred in Pennsylvania, resulting in the death of 5 persons.

## RECORD OF EXPLOSIONS BY STATES

Table 2 shows the record of explosions by States during the past 5 fiscal years. During the 5-year period 153 ignitions caused 764 deaths, an average of 30.6 ignitions and 152.8 deaths per year; this tabulation lists only the explosions with which the safety division of the United States Bureau of Mines had contacts of some kind. Both the ignitions and deaths during the past year were fewer than the average, but the number of deaths increased considerably over the previous year. For the 5-year period, July 1, 1928 to June 30, 1933, Pennsylvania heads the list both in total number of ignitions (36) and in deaths (125); Oklahoma ranks second in number of deaths (120), with only 9 ignitions. It is of interest to note that during the 5 years Kansas and Maryland had 1 ignition each, with a total of 3 deaths (2 in Kansas and 1 in Maryland); Tennessee had 3 ignitions, without a fatality, and Oklahoma went 1 year without a single ignition and another year with only 2 ignitions and no deaths. The following coal-mining States and territories are not listed in table 2 as having had an explosion or explosions during the past 5 fiscal years: Alaska, Arkansas, Iowa, Michigan, Missouri, Montana, North Dakota, Texas, and Wyoming. Although this does not mean necessarily that no explosions occurred in any of these States it means that the safety divisions of the United States Bureau of Mines has had no contact with explosions there during the period; on the other hand, the fact that these States do not appear in table 2 does indicate that no explosions with heavy loss either of life or of property occurred in any of them during the past 5 fiscal years.

## CAUSES OF EXPLOSIONS

Table 3 gives data as to causes of explosions in the mines of the United States during the past 5 fiscal years, as reported to the safety division of the United States Bureau of Mines. It will be noted that 153 explosions were studied during the 5-year period, an average of about 31 per year. There were 22 explosions during the fiscal year ended June 30, 1933, which is considerably belowthe average. Sixty-three (41.2 percent) of these explosions of the past 5 years were of electrical origin, 53 (34.6 percent) were caused by explosives, and 8 (5.2 percent) were of unknown origin. Explosions of electrical origin caused 36.4 percent of the explosions during the past year, an increase over the 2 preceding years but a considerable decrease over the first 2 years of the period and also lower than the average of 41.2 percent for the entire 5-year period; hence it is probable that much of the laxity in the use of electrical equipment in coal mines, which was alarmingly evident from 1925 to 1930, has now been corrected.

For the 5-year period, 34.6 percent of the mine explosions in the United States had open lights or smoking as the ignition cause; 36.4 percent were caused by open lights (none by smoking) during the past year, which is slightly above the average for the 5-year period. When the efficiency of the available types of closed lights is compared with that of available open lights, disregarding the numerous important safety features of closed lights, it is difficult to understand why the use of open lights in mines is continued or allowed. Smoking underground should be prohibited in all mines, and this can be done and in many mines is being done by supervision and discipline of the right kind.

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Table 2. - Record of explosions by States during last 5 fiscal years

| State | 1928-29 |  | 1929-30 |  | 1930-31 |  | 1931-32 |  | 1932-33 |  | 5 year totals |  | Averages per year |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Deaths | Ignitions | Deaths | Ignitions | Deaths | Ignitions | Deaths | Ignitions | Deaths | Ignitions | Deaths | Ignitions | Deaths | Ignitions |
| **Alabama** | 13 | 7 | 8 | 4 | 0 | 2 | 4 | 5 | - | - | 25 | 18 | 5 | 3.6 |
| **California** | 0 | 1 | 7 | 2 | 12 | 1 | 0 | 1 | 0 | 1 | 19 | 6 | 3.8 | 1.2 |
| **Colorado** | - | - | 0 | 1 | - | - | 4 | 3 | 1 | 1 | 5 | 5 | 1.0 | 1.0 |
| **Illinois** | 0 | 3 | 10 | 2 | 2 | 1 | 3 | 3 | 54 | 1 | 69 | 10 | 13.8 | 2.0 |
| **Indiana** | - | - | - | - | 28 | 1 | - | - | 4 | 2 | 32 | 3 | 6.4 | .6 |
| **Kansas** | 2 | 1 | - | - | - | - | - | - | - | - | 2 | 1 | .4 | .2 |
| **Kentucky** | 11 | 3 | 16 | 1 | - | - | 3 | 1 | 26 | 2 | 56 | 7 | 11.2 | 1.4 |
| **Maryland** | - | - | - | - | - | - | 1 | 1 | - | - | 1 | 1 | .2 | .2 |
| **New Mexico** | - | - | - | - | 8 | 3 | - | - | 14 | 1 | 22 | 4 | 4.4 | .8 |
| **Ohio** | 3 | 3 | 1 | 2 | 88 | 3 | - | - | - | - | 92 | 8 | 18.4 | 1.6 |
| **Oklahoma** | 1 | 1 | 71 | 4 | 45 | 2 | - | - | 3 | 2 | 120 | 9 | 24.0 | 1.8 |
| **Pennsylvania** | 70 | 9 | 16 | 8 | 23 | 7 | 7 | 6 | 9 | 6 | 125 | 36 | 25.0 | 7.2 |
| **Tennessee** | - | - | - | - | - | - | 0 | 3 | - | - | 0 | 3 | .0 | .6 |
| **Utah** | 1 | 2 | 30 | 3 | - | - | - | - | - | - | 31 | 5 | 6.2 | 1.0 |
| **Virginia** | 2 | 1 | - | - | - | - | 54 | 3 | - | - | 56 | 4 | 11.2 | .8 |
| **Washington** | - | - | 17 | 2 | 0 | 2 | - | - | 2 | 1 | 19 | 5 | 3.8 | 1.0 |
| **West Virginia** | 36 | 7 | 23 | 5 | 11 | 4 | 11 | 7 | 9 | 5 | 90 | 28 | 18.0 | 5.6 |
| **Total** | 139 | 38 | 199 | 34 | 217 | 26 | 87 | 33 | 122 | 22 | 764 | 153 | 152.8 | 30.6 |

Table 3. - Comparison of explosion-ignition causes, fiscal years 1928-29 to 1932-33, inclusive

| Years | Ignition by electricity | | Ignition by open lights or smoking | | Ignition by explosives | | Ignition by unknown causes | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | Number | Percent | Number | Percent | Number | Percent |
| 1928-29 | 18 | 47.4 | 11 | 29.0 | 8 | 21.0 | 1 | 2.6 | 38 | 100 |
| 1929-30 | 18 | 52.5 | 8 | 23.5 | 6 | 18.0 | 2 | 6.0 | 34 | 100 |
| 1930-31 | 9 | 34.6 | 11 | 42.3 | 6 | 23.1 | 0 | .0 | 26 | 100 |
| 1931-32 | 10 | 30.1 | 15 | 45.5 | 5 | 15.2 | 3 | 9.2 | 33 | 100 |
| 1932-33 | 8 | 36.4 | 8 | 36.4 | 4 | 18.1 | 2 | 9.1 | 22 | 100 |
| Total (5 year) | 63 | 41.2 | 53 | 34.6 | 29 | 19.0 | 8 | 5.2 | 153 | 100 |

During the past 5 years 19 percent of the explosions--as studied by the safety division of the United States Bureau of Mines--were caused by explosives; the number during the past year was 18.1 percent of the total for that year. Unquestionably there have been numerous explosions due to explosives in the coal mines of the United States during the past 5 years in addition to the 29 listed in table 3 that are not recorded in the table, as the representatives of the safety division do not come in contact with many shot-firing explosions, more especially those occurring on the "off shift" in coal mines, in which no life is lost or only 1 or 2 victims are caught. Nevertheless, explosives practice in the coal mines of the United States has been safeguarded much in late years by extending the use of permissible explosives, by substituting electrical methods for those that are less safe, by restricting blasting to the off-shift or to the end of the shift, and by other progressive changes in blasting practice; it will be unfortunate if the excellent results attained by these changes are lost by the present-day tendency toward reintroduction of blasting during the working shift, with the manifest possibilities for multiple deaths of underground workers if an explosion does occur.

## EXPLOSION FATALITIES BY CAUSES

Table 4 compares explosion fatalities by ignition causes as studied by the safety division of the United States Bureau of Mines and shows that during the past 5 fiscal years 764 fatalities occurred from explosions in the mines of the United States, an average of 153 per year. The record for the past year, 122 killed, is better than the average for the 5-year period; however, it is worse than the record of the preceding year, which was the best fiscal-year record of occurrence of fatalities from explosions in the mines of the United States in the present century.

Explosions of electrical origin were responsible for 55.7 percent of the deaths in our mines during the past 5 fiscal years; however, during the past year only 20.5 percent of the deaths were due to this cause. The deaths from this cause were considerably reduced during the past 2 years (25 in 1933 and 11 in 1932) compared with those in the first 3 years of this period (143 in 1931, 154 in 1930, and 93 in 1929).

That an average of 85 persons has been killed annually in our coal mines during the past 5 years because of explosions started by electricity is a record of which our mining and machinery industrial leaders should be anything but proud. The decrease in this type of mine accident during the past 2 fiscal years is gratifying, but there is cause for real anxiety as to what may transpire in the fall and winter of 1933-34, when apparently there will be a material increase in coal-mining activity, possibly with considerable carelessness or recklessness in the use of underground electrical equipment and devices. Our coal-mining people are confronted with a real problem in holding explosions to a minimum when or if this increased activity materializes; however, there is no question but that by the use of the right kind and the right amount of continually applied effort, explosions of electrical origin as well as from all other causes can be prevented.

Table 4. - Comparison of explosion fatalities by ignition causes, fiscal years 1927-28 to 1932-33

| Year | Electricity |  | Open lights |  | Explosives |  | Unknown |  | Total |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  | Number killed | Percent | Number killed | Percent | Number killed | Percent | Number killed | Percent | Number killed | Percent |
| 1928-29 | 93 | 66.9 | 14 | 10.1 | 26 | 18.7 | 6 | 4.3 | 139 | 100 |
| 1929-30 | 154 | 77.5 | 21 | 10.5 | 24 | 12.0 | 0 | .0 | 199 | 100 |
| 1930-31 | 143 | 65.9 | 56 | 25.8 | 18 | 8.3 | 0 | .0 | 217 | 100 |
| 1931-32 | 11 | 12.7 | 33 | 38.0 | 42 | 48.2 | 1 | 1.1 | 87 | 100 |
| 1932-33 | 25 | 20.5 | 63 | 51.6 | 29 | 23.8 | 5 | 4.1 | 122 | 100 |
| Total (5 years) | 426 | 55.7 | 187 | 24.5 | 139 | 18.2 | 12 | 1.6 | 764 | 100 |

Open lights (or smoking) caused explosions resulting in 187 fatalities during the past 5 fiscal years or 24.5 percent of the total fatalities from explosions during that period. During the past year there were 63 deaths from this cause or 51.6 percent of the total (34 in one explosion), which is considerably more than in any other year of the past 5. Three of the explosions during the past year were charged to smoking, all in anthracite mines.

It is disquieting to learn that while only 19 persons were killed in explosions started by open lights or smoking in the mines of the United States in the fiscal year ended June 30, 1929 and only 21 in the year ended June 30, 1930 there were 53 in 1931, 33 in 1932, and 63 in 1933, apparently indicating a decidedly upward trend in deaths due to explosions caused by open lights or smoking. The fact that every one of these deaths is utterly unnecessary makes the situation the more deplorable; every underground worker in the United States can and should be supplied with an up-to-date permissible electric cap lamp, which gives better and more dependable illumination than open lights; in addition, there is not an instance available of the loss of even one life from an explosion or a fire started in any mine in the United States by a permissible electric cap lamp, although the records show hundreds killed in one manner or another from the use of open lights.

During the past 5 fiscal years 139 persons have been killed in explosions initiated by explosives, or 18.2 percent of the total killed during this period from all causes. During the past year 29 persons (23.8 percent of the total killed in mine explosions in the United States) were killed in explosions started by blasting or explosives; 23 of these deaths resulted from one explosion caused by dust ignited by a blown-out shot.

The average number killed annually in explosions started by blasting or explosives in our mines during the past 5 years--28--has been exceeded in only 2 years, 1932-33 with 29 and 1931-32 with 42. As previously indicated, the record for the past 5 years (even including the past 2 years) is a vast improvement over what transpired in our coal mines 10, 15, 20, or more years ago. The tendency now is toward extension of the use of explosives and of blasting in mines while the working shift is present; this is unfortunate, and there is reason for the feeling of apprehension now entertained by many, if not most, coal-mine safety men that the increased use of explosives and of blasting during the working shift is virtually certain to increase explosions as well as individual accidents in our coal mines, notwithstanding alleged precautions as to devices, methods, and equipment.

During the past 5 fiscal years 12 persons have been killed in 8 explosions in mines of the United States, and the cause of the explosions has not been ascertained in so far as data could be obtained by the safety division of the United States Bureau of Mines.

## ELECTRICAL CAUSES OF EXPLOSIONS

Table 5 gives data relating to causes of explosions of electrical origin in mines of the United States during the past 5 fiscal years in so far as data are available to the safety division of the United States Bureau of Mines. The ignitions by electricity totaled 63 for the 5 years, with 8 causing 25 fatalities during the past fiscal year. The greatest source of electrical ignition in coal mines is from trolley or cable-reel locomotives and from nonpermissible mining machines; these two sources, plus trolley wire, were responsible for more than one half of the electrical ignitions during the past 5-year period.

During 1932 trolley or cable-reel locomotives were responsible for 4 ignitions, resulting in 6 fatalities and 3 injuries; a nonpermissible mining machine ignited gas in one mine, killing 2 men and severely burning 4 others; an arc from the controller of a nonpermissible underground-slope hoist ignited gas, killing 1 man and injuring 1 other; an arc from a signal wire on a slope caused an explosion that killed 14 persons; and 2 men were killed by an explosion, the exact source of the electric arc not being determined.

As is true in most electrical ignitions there was evidence of carelessness in maintaining good ventilation in the places where the electrical ignitions occurred during the past 5 years, as well as during 1932-33. In several cases proper inspection of the places had not been made; and in some instances working faces were driven too far ahead of the last open crosscut without proper provision for keeping air circulation at or near the face, and the use of haulageways as return airways, always hazardous, resulted in several explosions.

In one case a mine foreman and a fire boss entered a mine on a trolley locomotive to make an inspection shortly after starting the fan, which had not been in operation for about 100 hours. When they had reached a point about 7,600 feet inby a circuit breaker was thrown into contact, and evidently an arc was formed somewhere along the trolley line in a section of the mine, igniting the gas that had accumulated while the fan was idle. The use of trolley locomotives by fire bosses is dangerous, especially after the fan has been stopped for a considerable period, and this is by no means the only instance in which this practice has resulted disastrously. The use of haulageways on return air, either in gassy or so-called nongassy mines, is another dangerous practice, even though it is in more or less general use, especially in some districts; haulage by electricity, particularly by trolley or cable-reel locomotive, is at all times a potential source of trouble when on return air in mines known to give off explosive gas.

Table 5. - Electrical causes of explosions

| Cause | Number of ignitions | | | | | Total, 5 years | Number killed | | Number injured | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1928-29 1/ | 1929-30 2/ | 1930-31 3/ | 1931-32 4/ | 1932-33 | | 1931-32 | 1932-33 | 1931-32 | 1932-33 |
| Trolley or cable-reel locomotive ....... | 5/ 5 | 5 | 1 | 1 | 4 | 5/ 15 | 0 | 6 | 2 | 3 |
| Nonpermissible mining machine .......... | 6/ 5 | 5 | 3 | 3 | 1 | 6/ 16 | 7 | 2 | 7 | 4 |
| Nonpermissible electric motor ....... | 4 | 3 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 |
| Nonpermissible shot-firing battery ... | 0 | 7/ 2 | 7/ 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Cable nips or cable blowout .......... | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Nonpermissible electric drill ....... | 0 | 0 | 0 | 2 | 0 | 2 | 1 | 0 | 6 | 0 |
| Nonpermissible storage-battery locomotive ....... | 1 | 1 | 2 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| Nonpermissible electric hoist ....... | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| Faulty wiring ....... | 2 | 2 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| Trolley wire ........ | 1 | 0 | 2 | 1 | 0 | 4 | 2 | 0 | 0 | 0 |
| Electric arc ........ | 2 | 0 | 1 | 2 | 1 | 6 | 1 | 2 | 3 | 0 |
| Signal wire ......... | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 14 | 0 | 0 |
| Total ignitions ..... | 18 | 18 | 9 | 10 | 8 | 63 | 11 | 25 | 18 | 8 |

1/ See Inf. Circ. 6178.
2/ See Inf. Circ. 6419.
3/ See Inf. Circ. 6540.
4/ See Inf. Circ. 6680.
5/ 1 not included in totals; may have been from open light, hence is assigned to open lights or smoking.
6/ 1 not included in totals; may have been from smoking, hence is assigned to open lights or smoking.
7/ 1 not included in totals; may have been from overcharged shot, hence is assigned to explosives accidents.

# COMPARISON OF LIGHTING IN MINES WHERE EXPLOSIONS OCCURRED DURING THE PAST 5 YEARS

In a comparison of lighting in mines where explosions occurred during the past 5 fiscal years, as shown in table 6, it is observed that of 155 explosions listed 60 (38.7 percent of the total) occurred in open-light mines, that 88 (56.8 percent) were in closed-light mines, and that in 7 (4.5 percent) the lighting practice was unknown. The fact that the greater number of these explosions occurred in closed-light mines indicates failure to correct other unsafe features, such as inadequate ventilation, use of nonpermissible electrical equipment, use of unsafe explosives, and dangerous methods of employing explosives and electrical equipment.

In most instances closed lights (which as far as general working purposes are concerned in the coal mines of the United States at this time means use of permissible electric cap lamps) have been employed because the management feared the mine had gas or dust conditions such that the use of open lights presented a possible ignition agency; this has resulted in the use of closed lights in most of the highly hazardous mines, where the danger from explosion is greatest. Therefore it might be natural to expect these mines to have the greatest number and percentage of explosions if it were not for the fact that these so-called more dangerous mines can, if they will, protect themselves and their employees from explosions by adopting and keeping in effect readily available measures that will absolutely prevent occurrence of explosions in these mines. Hence the occurrence of explosions in closed-light mines cannot be correctly interpreted as due to the closed lights but as due entirely to neglect or carelessness of some kind in the closed-light mine which has the explosion. There has never been an explosion caused by an approved electric cap lamp, but the introduction of these lamps into some mines has in numerous instances tended to cause relaxation of other common-sense safety precautionary measures.

In one explosion during the past year in a so-called nongassy mine open lights caused a gas ignition, with subsequent explosion, killing 54 men; in another mine known to be gassy open lights caused an explosion in which a surveying party of three was killed. In both explosions the ventilation system was inadequate due to an attempt to operate with a continuous air-current circulation and the supplementary use of booster fans. These practices indicate either lack of knowledge of efficient ventilation methods or wanton disregard of sane and safe practices.

Every year has its quota of explosions started by open lights in so-called nongassy mines, and generally (though not invariably) the occurrence of the explosions leads to the substitution of closed lights for open. Open lights should not be allowed in any mine, coal or non-coal, as they add unnecessary hazards to the already far too numerous dangers that confront the underground worker; and to allow the use of open lights in mines known to give off explosive gas, whether in large or small amount, is little short of criminal negligence when it is realized that ignition of as small a quantity as 150 to 200 cubic feet of an explosive mixture of methane and air under certain conditions can precipitate a widespread explosion which might, probably would, kill every person in the mine.

Table 6. - Comparison of lighting in mines where explosions occurred, fiscal years 1927-28 to 1932-33, inclusive

| Years | Open lights | | Closed lights | | Lighting unknown | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Number of explosions | Percent | Number of explosions | Percent | Number of explosions | Percent | Number of explosions | Percent |
| 1928-29 | 18 | 47.4 | 19 | 50.0 | 1 | 2.6 | 38 | 100 |
| 1929-30 | 8 | 23.5 | 25 | 73.5 | 1 | 3.0 | 34 | 100 |
| 1930-31 | 12 | 44.4 | 15 | 55.6 | 0 | .0 | 1/ 27 | 100 |
| 1931-32 | 15 | 44.1 | 15 | 44.1 | 4 | 11.8 | 1/ 34 | 100 |
| 1932-33 | 7 | 31.8 | 14 | 63.6 | 1 | 4.6 | 22 | 100 |
| Total (5 years) | 60 | 38.7 | 88 | 56.8 | 7 | 4.5 | 2/155 | 100 |

1/ One mine had mixed (open as well as closed) lighting.
2/ Mines had mixed (open as well as closed) lighting.

Table 7. - Summary of mine fires by States - July 1, 1930 to June 30, 1933

| | Lights | | | | Fatalities by ignition causes | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Electricity | | Open lights | | Explosives | | Miscellaneous | | | |
| | Open | Closed | Unknown | Total | Deaths | Igni-tions | Deaths | Igni-tions | Deaths | Igni-tions | Deaths | Igni-tions | Deaths | Igni-tions |
| Alabama | - | - | 1 | 1 | - | 1 | - | - | - | - | - | - | - | 1 |
| Colorado | 1/ 2 | 1 | - | 3 | - | - | - | - | - | - | - | 3 | - | 3 |
| Illinois | 1 | 1 | - | 2 | - | 1 | - | - | - | - | - | 1 | - | 2 |
| Indiana | 2 | - | - | 2 | - | - | - | - | - | 2 | - | - | - | 2 |
| Kentucky | 2 | - | 2/ 5 | 7 | - | 2 | - | - | - | - | 2/ 1 | 5 | 1 | 7 |
| Missouri | 3/ 1 | - | - | 1 | - | - | - | - | - | - | - | 1 | - | 1 |
| Montana | 3/ 1 | - | - | 1 | - | - | - | - | - | - | - | 1 | - | 1 |
| New Mexico | - | 1 | - | 1 | - | - | - | - | - | - | - | 1 | - | 1 |
| Pennsylvania | - | 2 | 3/ 2 | 4 | - | 1 | - | - | - | - | - | 3 | - | 4 |
| South Dakota | 1 | - | - | 1 | - | - | - | - | - | - | - | 1 | - | 1 |
| Tennessee | 1 | - | - | 1 | - | - | - | - | - | - | 1 | 1 | 1 | 1 |
| Utah | 1/ 1 | - | - | 1 | - | 1 | - | - | - | - | - | - | - | 1 |
| Virginia | - | - | 1 | 4/ 1 | - | - | - | - | - | - | - | 1 | - | 1 |
| West Virginia | - | 1 | - | 1 | - | 1 | - | - | - | - | - | - | - | 1 |
| Total fiscal year, ended June 30, 1933 | 12 | 6 | 9 | 27 | - | 7 | - | - | - | 2 | 2 | 5/ 18 | 2 | 27 |
| Total fiscal year 6/, ended June 30, 1932 | 8 | 5 | 8 | 21 | 1 | 8 | 0 | 0 | 0 | 3 | 0 | 10 | 1 | 21 |
| Total fiscal year 7/ ended June 30, 1931 | 12 | 7 | 5 | 24 | 0 | 7 | 5 | 3 | 0 | 5 | 18 | 9 | 23 | 24 |
| Total fiscal year 8/ ended June 30, 1930 | 7 | 8 | 9 | 24 | 2 | 9 | 3 | 6 | 0 | 3 | 0 | 6 | 5 | 24 |

1/ Metal mine.

2/ Tipple fire burned rope, cage dropped and caught 5 men placing rail across top of shaft - 1 killed, 4 injured.

3/ Abandoned mine.

4/ Fire in coal-storage bin near tipple.

5/ Eight of these fires were from spontaneous combustion

6/ See Inf. Circ. 6680, issued January 1933.

7/ See Inf. Circ. 6540, issued December 1931.

8/ See Inf. Circ. 6419, issued January 1931.

Note. - This tabulation includes data only on mine fires to which the attention of the

## MINE FIRES

Although mine fires have potentialities of causing great loss of life and tremendous property damage the mines of the United States have been fortunate during the past decade in not experiencing a fire causing large loss of life; however, there have been a number of fires that have caused considerable property damage.

During the past fiscal year 27 mine fires--5 in metal mines--were called to the attention of the safety division of the United States Bureau of Mines. Unquestionably, scores of other fires occurred which were detected and extinguished promptly without much damage, hence their occurrence was not made public. Table 7 shows that most of the fires in 1932-33 which were contacted by the safety division forces were in Kentucky, the coal mines of this State being listed as having 7 fires, with 1 fatality; this fatality can be charged only indirectly to a mine fire, as the man was killed by a falling cage when a fire in the tipple burned the rope. Four fires occurred in Pennsylvania, 2 in abandoned mines, which threatened the destruction of much valuable city property. Three fires occurred in Colorado, 1 in a metal mine, 2 each in Illinois and Indiana, and 1 each in Alabama, Missouri (metal mine), Montana (metal mine), New Mexico, South Dakota, Tennessee, Utah (metal mine), Virginia, and West Virginia. One death resulted in a State convict mine when a prisoner set fire to some timbers. It is noted that nearly one third of the fires the causes of which are known were due to electricity, 2 were caused by explosives, and 8 were of spontaneous origin.

## SUMMARY

The encouraging factor in connection with explosions is that during the past 5 years the trends in the number of explosions and deaths from explosions have been definitely downward. Although the depressed condition of the coal industry during the past few years may have influenced the downward trends, it is believed that the greatest factors in the reduced frequency and severity of explosions are (1) increased activities of various kinds by State mine-inspection departments, especially along the line of educational work; (2) the rapidly growing realization of the economic waste of all accidents, including explosions, and the more or less general acceptance of responsibility for accident occurrence by the mine operators; and (3) the more widespread dissemination of safety data by the United States Bureau of Mines and other safety organizations.

It is definitely known that mine explosions and fires can be prevented, the problem being chiefly a matter of education and adoption of known preventive measures, the expense of which is negligible when compared with probable (in many instances) actual saving.

Salient points brought out in the study of mine explosions and fires in mines of the United States coming to the attention of the safety division of the United States Bureau of Mines for the year ended June 30, 1933, are as follows:

1. Twenty-two explosions were studied, 16 in bituminous mines, 5 in anthracite mines, and 1 in a metal mine, compared with 33 for the previous year and an average of 30 per year for the past 5 fiscal years.

2. Explosions took 122 lives last year compared with 87 the previous year and an average of 153 annually for the past 5 fiscal years.

3. The 3 major explosions accounted for 91 deaths, while the 19 lesser explosions accounted for 31 deaths. All major explosions (those in which 5 or more persons were killed) occurred in one month (December 1933), hence the remaining 11 months of the fiscal year ended June 30, 1933 were free of major explosion disasters in the mines of the United States, an all-time record of avoidance of major explosion disasters in American mines in so far as records are available.

4. Seven explosions were in open-light mines compared with 15 the year before, an average of 12 annually for the past 5 fiscal years; 14 explosions were in closed-light mines compared with 15 the previous year, an average of 17.6 annually for the past 5 fiscal years. Some of the open-light mines in which explosions occurred were known to give off explosive gas, in some instances in considerable quantities.

5. Eight explosions, causing 25 deaths, were of electrical origin compared with 10 explosions and 11 deaths for the previous year. While the number of explosions caused by electricity decreased the deaths from this cause increased more than 50 percent. Explosions of electrical origin averaged 12.6 in number annually for the past 5 fiscal years, and deaths averaged 85.2 annually for the same period; hence, both of the past 2 fiscal years show a decided improvement in this phase of explosion occurrence in United States mines.

6. West Virginia, with 4 explosions, ranks first in the number of explosions caused by electricity during the year; and New Mexico, with 14 fatalities, ranks first in the number of deaths from this cause.

7. Trolley or cable-reel locomotives were responsible for 4 of the 8 explosions of electrical origin, while a nonpermissible mining machine, a nonpermissible electric hoist, a signal wire, and an electric arc were responsible for 1 each; the explosion caused by an arc from a signal wire caused 14 fatalities.

8. Eight explosions, with 63 deaths, were caused by open lights or smoking, compared with 15 explosions and 33 deaths in the previous year. One of these open-light explosions, which occurred in December 1932, killed 54 persons.

9. Four explosions and 29 deaths were caused by the use (or probably more nearly correctly the misuse) of explosives, compared with 5 explosions and 42 deaths in the previous year.

10. Rock-dust was used to some extent in at least 7 of the mines in which explosions occurred during the last fiscal year. It was effectively applied in only 3 mines; in 2 of the mines in which explosions occurred rock-dust is credited with stopping the spread of the explosions, and it is believed that this saved the lives of many if not all of the approximately 300 persons who were in these mines at the time of the explosions and who escaped essentially uninjured.

11. Eighteen of the explosions during the past year were initiated by gas and 4 by coal dust.

12. The underlying cause of at least 81 of the 122 deaths resulting from explosions during the past year was defective ventilation, and this was manifest in both open and closed-light mines.

13. During 1932-33 the personnel of the safety division of the United States Bureau of Mines reported on 27 mine fires, 22 in coal mines and 5 in metal mines, compared with 21 fires in 1931-32 and 24 in each of the 2 years before that.

14. Nearly two thirds of the fires for the past year, of which the causes are definitely known, were initiated by electricity. Two mine fires were caused by explosions, and at least 8 were of spontaneous origin.

15. The activities of United States Bureau of Mines personnel during the past fiscal year included contacts with 7 mine fires in Kentucky, 4 in Pennsylvania, 3 in Colorado, 2 each in Illinois and Indiana, and 1 in each of the following States: Alabama, Missouri, Montana, New Mexico, South Dakota, Tennessee, Utah, Virginia, and West Virginia.

## CONCLUSION

The data in this publication were compiled in the same manner as in previous years (see Inf. Circs. 6178, 6419, 6540, and 6680) and embody only facts brought out during fairly close study by field employees of the safety division of the United States Bureau of Mines. Although an attempt is made to obtain data on every mine explosion that occurs in the United States some of the less destructive explosions are not brought to the attention of the Bureau early enough to allow an investigation to be made; rarely, if ever, however, does the Bureau fail to get fairly complete data on mine explosions in which more than one life is lost or in which any considerable amount of property is damaged. Hence the data in the publications are relatively complete as to mine explosions, especially those causing loss of more than one life. The data on fires are by no means as nearly complete and inclusive as those for explosions, and there is good reason to believe that scores of mine fires (many of them in metal mines) occur annually without having been made known to the United States Bureau of Mines or even the State inspection forces. Mine fires are of almost daily occurrence with some coal-mining companies, particularly at shot-firing time or where the coal fires spontaneously, and fires of electrical origin or from open lights are by no means unusual in metal mines when they are working fairly close to capacity.

The facts obtained from a detailed study of available data on explosions and fires in the mines of the United States during the past 5 or 6 fiscal years are decidedly encouraging to those who year after year despaired of ever having the mines of the United States operated with reasonable freedom from explosion disasters. For the 15-year period prior to 1929 explosions took an average of about 265 lives annually in the coal mines of the United States; and since that date, according to data in tables 1 and 4, the number of fatalities from explosions in the mines of the United States has never been as high as this average figure of 265 per year, being 139 in the fiscal year ended June 30, 1929, 199 in 1930, 217 in 1931, 87 in 1932, and 122 in 1933, the average for the last 5 fiscal years being 153, or very much lower than the 265 for the previous 15 years.

The decreasing number of explosions of electrical origin and of fatalities from them during the past 2 years is especially encouraging, as there had been an alarming increase in explosions of electrical origin and of their very heavy fatality results for several years before 1930 or 1931. It now appears that although mechanization of mines is proceeding (even though at a somewhat reduced rate recently) it is being done with reasonable regard to the hazards involved and apparently with much more attention to overcoming or eliminating those hazards than in 1924 to 1928, inclusive.

The fact that no explosions of gas or dust are listed as having occurred during the past 5 fiscal years in coal mines in Alaska, Arkansas, Iowa, Michigan Missouri, Montana, North Dakota, Texas, and Wyoming is significant, especially as to Arkansas and Wyoming, both of which have in the past been rather prone to have explosions. Pennsylvania did not have a major explosion disaster in either bituminous or anthracite mines during the past fiscal year, an exceptionally fine performance; in fact, Pennsylvania has not had a major mine explosion since May 29, 1931, or including 2 fiscal years. Pennsylvania, with bituminous mines employing approximately one fourth of the coal miners of the United States and producing about one fourth of the country's coal, much of it from mines with inherently dangerous conditions as to gas and dust, has not had a major explosion disaster (one with 5 or more lives lost) since March 21, 1929, or more than 4½ years at this writing (September 1, 1933); the anthracite mines of Pennsylvania, employing about one fifth of the miners of the United States, many of them in gassy, steeply pitching coal beds, have not had a major explosion disaster since May 29, 1931, or about 2-1/3 years as this is being written. West Virginia, with the number employed and tonnage produced but slightly less than in Pennsylvania bituminous operations and with its numerous gassy and dusty mines, has not had a major explosion since November 3, 1931, or nearly 2 years. Alabama, with numerous hazards in its coal mines, has not had a major explosion since December 28, 1931, or nearly 2 years; during that period only 1 person was killed in Alabama coal mines from ignitions of gas or dust. Colorado, with its dangerous coal-mining conditions and very bad explosion record prior to 1920, has not had a major coal-mine explosion since May 27, 1927, or nearly 6½ years, and has had only two major coal-mine disasters (one with 7 fatalities and one with 6) in the past 10 years. Utah, with the worst fatality rate from coal-mine explosions of any

State in the Union, has not had a major coal-mine explosion since March 8, 1930, and Wyoming, with a bad past as to occurrence of coal-mine explosion disasters, has avoided them since September 16, 1924, or 9 years. Oklahoma has not had a major explosion since October 27, 1930, or nearly 3 years; and Washington has not had one since April 12, 1930, or $3\frac{1}{2}$ years. Thus it appears that at least eight important coal-mining States with bad records as to occurrence of coal-mine disasters have in recent years been relatively free of them, indicating that our coal-mining people at last realize that coal-mine explosions are preventable if readily available methods, devices, and equipment are put into effect and kept in effect.

The three major explosions of the past fiscal year all occurred in December 1932, hence for 11 months of the fiscal year the mines of the United States were free of major disasters, a truly fine record. The calendar year 1933 to date of writing this paper (September 1, 1933) has been free of major explosion disasters in the mines of the United States, and there has not been a major explosion disaster since December 23, 1932, unquestionably the longest continuous period of immunity from major explosion disasters in the available records of mining in the United States.

With the new industrial conditions brought about by the codes of the National Recovery Administration about to go into effect as this is written, there will undoubtedly be numerous changes in mining practice in many States; inasmuch as the codes applied to mining contain essentially nothing with reference to safe operation, unless much extra effort is taken by our mining people toward the safety phases of working our mines there are likely to be numerous relaxations and inefficiencies in our mines, with attendant increased accident rates and probably with increased occurrence of mine disasters. To avoid any such unfortunate condition it is hoped that increased rather than diminished attention will be paid to prevention of accidents, including explosion disasters, in our mines and that at least some attention will be devoted to this important phase of mining when the codes are placed in actual working practice.